

REMARKS

Applicant has carefully studied the nonfinal Examiner's Action mailed May 26, 2004 and all references cited therein. The amendment appearing above and these explanatory remarks are believed to be fully responsive to the Action. Accordingly, this important patent application is now believed to be in condition for allowance.

Applicant responds to the outstanding Action by centered headings that correspond to the centered headings employed by the Office, to ensure full response on the merits to each finding of the Office.

Claim Rejections - 35 U.S.C. § 103

Applicant acknowledges the quotation of 35 U.S.C. § 103(a).

Claims 1 through 6 and 8 through 20 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Hayes in view Ogden or Sumpster.

The Hayes reference teaches the use of a sol-gel chemistry-based Ucon-coated column for capillary electrophoresis, specifically capillary zone electrophoresis (CZE). A CZE column utilizes a single, mobile, phase and does not possess a stationary phase. In CZE, separation is based on the differences in the migration rates of the ionic solutes placed in a high electric field. Unlike gas chromatography, such as the present invention, no solute/stationary phase is necessary or utilized to achieve separation in CZE. In contradistinction, any interaction of the solutes with the column surface leads to loss of separation efficiency in CZE. As such, CZE columns are designed to eliminate such interactions.

The present invention discloses a sol-gel capillary column for use in gas chromatography (GC) and describes a novel method for creation of a sol-gel *stationary phase* coating to provide differential solute-stationary phase interactions responsible for the chromatographic separation of solute molecules. Utilizing the present invention, differential interactions between the analytes and the stationary phase, in the form of the surface coating, at the molecular level represent the key factors responsible for GC separation. The design of the present invention provides a novel capillary column which enhances such differential interactions.

Sol-gel CZE columns, such as those provided in the Hayes article, are designed to separate electrically charged (ionic) analytes. Accordingly, CZE cannot be applied to neutral compounds. Furthermore, CZE columns achieve separation of the ionic analytes in the *liquid*

phase. The GC column of the present invention separates electrically neutral (non-ionic) analytes in the *gas phase*, no liquid phase is present.

Furthermore, the Hayes article describes a column with a *chromatographically inert surface coating* on the inner walls of a fused silica capillary specifically to prevent solute/capillary surface interactions. The design of the present invention provides an approach to facilitate solute/stationary phase interactions which are essential for chromatographic separation. The interactions are facilitated through the creation of a *chromatographically active* sol-gel stationary phase coating on the inner surface of a fused silica capillary. The coating provides the added benefit of minimizing, or avoiding, the deleterious effects of solute adsorption through column deactivation. Chromatographic inertness of the surface coating renders sol-el CZE columns *unsuitable* and *ineffective* for chromatographic separations.

The Hayes article discusses a sol solution obtained by mixing the following ingredients:

- Tetraethoxysilane (400 μ l) (pre-cursor)
- Methyl formate (500 μ l)
- Formamide (100 μ l)
- Ucon 75-H-90000 (20 mg) (polymeric coating material)
- Hexamethyldisilazane (30 μ l)
- 0.1 M dicumyl peroxide in pentane (20 μ l) (cross-linking initiator)
- 0.5 M ethanolamine solution in methanol-deionized water

The instant application, however, expressly states that the sol-gel solution used to coat the lining of the capillary is prepared using:

- 0.4 g of hydroxyl-terminated PDMS
- methylene chloride (400 μ l)
- methyltrimethoxysilane (MTOS)
- 0.085 g of polymethylhydrosiloxane (PHMS)
- 200 μ l of TFA with 5% (v/v) of added water

The Office has pointed out that the Hayes article presents a sol-gel solution containing, *inter alia*, a cross-linking agent.¹ The presence of the cross-linking agent, dicumyl peroxide (DCP), causes the production of free radicals by thermal decomposition. (See Hayes, scheme 4).

¹ Office Action, page 2, ¶3

The Hayes article employs the use of this powerful free-radical initiator (e.g. dicumyl peroxide) to create a highly cross-linked polymeric structure to shield the capillary surface and to prevent solute-capillary surface interaction. Such a highly cross-linked structure leads to a loss in the ability of the polymer to serve as a chromatographic stationary phase.

Free radical cross-linking reactions propose significant drawbacks to GC methods. These cross-linking reactions are difficult to control to ensure the same degree of cross-linking in different columns with the same stationary phase. Cross-linking reactions also lead to significant changes in the polymer structure. These problems therefore make consistency in the preparation of multiple columns difficult. The present invention, however, does not use free-radical initiators (such as DCP) in the preparation of the stationary phase coating in the columns. As a result, the organic polymer used in creating the stationary phase coating is allowed to retain its natural non-cross-linked structure by the virtue of which it is able to provide chromatographic interaction with the solute molecules. Resultantly, the problems associated with free-radical production as a result of thermal breakdown do not exist.

Independent claim 1 has been amended to include the limitation of a surface-bonded sol-gel coating with a non-crosslinked organic ligand and is therefore believed to be in condition for allowance. Claims 2 through 5 depend, as well as claims 12 through 15, from claim 1 and therefore contain all limitations set therein and are patentable as a matter of law. In addition to remarks made herein, further support for this limitation is provided in the specification on page 4, line 9 through page 5, line 2.

Independent claims 6 and 10 have also been amended to include the limitation of providing a sol-gel solution and stationary phase, respectively, with a non-crosslinked organic ligand and are believed to be in condition for allowance. Since the remaining claims depend from these independent claims, which now include unanticipated and non-obvious limitations, they are patentable as a matter of law.

Furthermore, claims 1, 6 and 10 have been amended to remove the limitation "a silanol group containing" which has been replaced with "a sol-gel-active functional group." Silanol is one of many sol-gel-active functional groups. In support of this amendment, see, *inter alia*, page 19 of the instant application, lines 5-21.

The limitation, "that has been subjected to a hydrothermal treatment" has likewise been withdrawn.

The Office has requested that Applicant provide a copy of reference number 32 from the Hayes article, a copy of which is attached hereto.

The reference represents Applicants previous work and discusses the preparation of capillary columns for use in GC using a base-catalyzed *non-aqueous* sol-gel process. A non-aqueous process differs significantly from that of the instant invention in that it does not involve hydrolytic polycondensation. The sol solution of the prior art does not contain water and as a result the sol-gel reaction follows a non-hydrolytic pathway. The sol solution of the present invention does contain water and the sol-gel reactions proceed though hydrolysis of the sol-gel precursor(s) followed by polycondensation reactions between the hydrolysis products and other sol-gel-active components of the solution.

The experimental section of the article (page 506) calls for the use of *anhydrous* methyl formate and the Results and Discussion section (page 507) expressly states the subject matter involves a *nonaqueous-sol-gel* technique for the preparation of open tubular GC columns.

In the specification, page 29, lines 12 through 17, it is established that:

The key sol-gel reactions involved in the coating procedure are: (I) catalytic *hydrolysis* of the alkoxide precursor, (II) *polycondensation* of the hydrolyzed products into a three-dimensional sol-gel network, (III) chemical bonding of hydroxyl-terminated PDMS to the evolving sol-gel network, and (IV) chemical anchoring of the evolving sol-gel polymer to the inner walls of the capillary.

The specification clearly establishes the importance of water in the preparation of the sol-gel and is therefore not merely a design choice. Accordingly, the present invention has significant, and patentably distinct, features over the prior art.

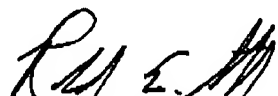
In light of the foregoing, the 35 U.S.C. § 103(a) rejection of Hayes in view Ogden or Sumpter (relating to a hydrothermal treatment) is believed to be moot. None of the references cited contain a provision for a sol-gel coating with a non-crosslinked organic ligand and therefore cannot be combined to achieve the instant invention.

Conclusion

Entry of a Notice of Allowance is solicited. If the Office is not fully persuaded as to the merits of Applicant's position, or if an Examiner's Amendment would place the pending claims in condition for allowance, a telephone call to the undersigned at (727) 507-8558 is requested.

Very respectfully,

SMITH & HOPEN

By: 

Dated: November 24, 2004

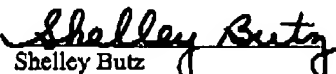
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CERTIFICATE OF FACSIMILE TRANSMISSION

(37 C.F.R. 1.8(a))

I HEREBY CERTIFY that this Amendment A, including Amendments to the Claims, and Remarks, is being transmitted by facsimile to the United States Patent and Trademark Office, Art Unit 1743, Attn: Arlen Soderquist, (703) 872-9310 on November 24, 2004.

Dated: November 24, 2004


Shelley Butz